INDOOR AIR QUALITY REASSESSMENT

Hopedale Junior-Senior High School
25 Adin Street
Hopedale, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Mr. Leonard Izzo, Hopedale Health Department and Mr. Phil Rinehart, Supervisor of Buildings and Grounds, Hopedale Public Schools, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at Hopedale Junior/Senior High School.

On October 29, 2004, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Mr. Izzo and Mr. Rinehart, during the assessment. BEHA previously visited the school in September of 2003 to conduct an indoor air quality assessment primarily focused on mold in the computer room. A report was issued by MDPH in 2003. The purpose of the most recent visit was to investigate possible causes of increased symptoms (e.g., exacerbation of allergies, headaches, sinus irritation) experienced by occupants in second floor interior classrooms, particularly classroom 221.

Actions on Recommendations Previously Made by MDPH

As previously discussed, BEHA staff visited the building in September 2003 and issued a report that made recommendations to improve indoor air quality (MDPH, 2003). A summary of actions taken on previous recommendations is included as Appendix A of this reassessment.

Methods

BEHA staff conducted a visual inspection for potential allergens/asthmagens, microbial growth and/or water damaged building materials. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school has a student population of approximately 400 and a staff of approximately 65. Tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in all but one area surveyed (Table 1), indicating inadequate airflow in this area of the school. However, the one room with carbon dioxide levels below 800 ppm had low occupancy at the time of the assessment; therefore, carbon dioxide levels do not reflect those that would be expected with full occupancy.

Fresh air is provided to interior classrooms by rooftop air-handling units (AHU) (Picture 1) that are ducted to classrooms via two ceiling-mounted air diffusers located near the rear of the classroom (Pictures 2 and 3). Exhaust ventilation is provided by two return vents located at the front of each classroom (Picture 4); these exhaust vents are ducted back to the AHUs. These systems were functioning during the assessment. As a result of indoor air complaints from the previous BEHA assessment (MDPH, 2003), high efficiency pleated air filters were installed to improve air quality (Picture 5). It is important to note, however, (as indicated in the 2003 report) that increasing filtration can reduce airflow (called pressure drop), which can subsequently reduce the efficiency of the AHU to deliver air due to increased resistance.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The initial equipment balancing occurred after the installation of the new HVAC systems in 2002.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix B.

Temperature measurements ranged from 71 ^{o} F to 74 ^{o} F, which were within the BEHA's recommended comfort range of 70 ^{o} F to 78 ^{o} F. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in areas surveyed on the day of the assessment ranged from 34 to 36 percent, which were slightly below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

At the time of the BEHA assessment, several water damaged ceiling tiles were observed in classroom 221 as a result of a roof leak (Pictures 6 and 7). The ceiling tiles were pointed out to Mr. Rinehart, who replaced them during the assessment (Picture 8). Mr. Rinehart reported that the roof leak, which was the source of moisture above these ceiling tiles, had been identified and patched. BEHA staff accompanied Mr. Rinehart to the roof and observed the roof patch which was located above classroom 221 (Picture 9). BEHA staff also recommended sealing holes/breaches in the concrete decking in the classroom (Picture 10) as a secondary barrier. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

Other Concerns

Indoor air quality can also be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter. As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detectable (ND). Carbon monoxide levels measured in the school were also ND (Table 1).

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter (μg/m^3) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, the US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 65 μg/m^3 over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 23 μg/m^3 at the time of the assessment. PM2.5 levels measured indoors ranged from 8 to 22 μg/m^3 which were below background, and well below the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While TVOC levels were ND, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may also contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products and other chemicals were seen on counter tops in classrooms (Picture 11). Cleaning products consisting of VOC-containing chemicals (e.g., bleach or ammonia-related compounds) can be irritating to the eyes, nose and throat. These items should be stored properly and out of the reach of students.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Contact the school's HVAC vendor to determine if the introduction of outside air via the rooftop AHUs can be increased using high-efficiency filters currently installed.
2. Ensure roof leaks are repaired. Repair/replace any remaining water-damaged ceiling tiles. Examine above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Building occupants should report any roof leaks or other signs of water penetration to school maintenance staff for prompt remediation.
3. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
6. Discontinue the use of VOC-containing cleaners. Less irritating materials (e.g. soap and water) may suffice to clean these areas.
7. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (US EPA, 2001) for further information on mold and/or mold clean up. Copies of this document are available from the US EPA at: http://www.epa.gov/iaq/molds/mold_remediation.html.
8. Consider adopting the US EPA (2000b) document, "Tools for Schools" to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
9. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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Picture 1

Rooftop AHU

Picture 2

Ceiling-Mounted Vent (Note Supply and Return Vents are of Similar Design)

Picture 3

Location of Supply Vents to the Rear of the Classroom

Picture 4

Location of Return Vents at the Front of the Classroom

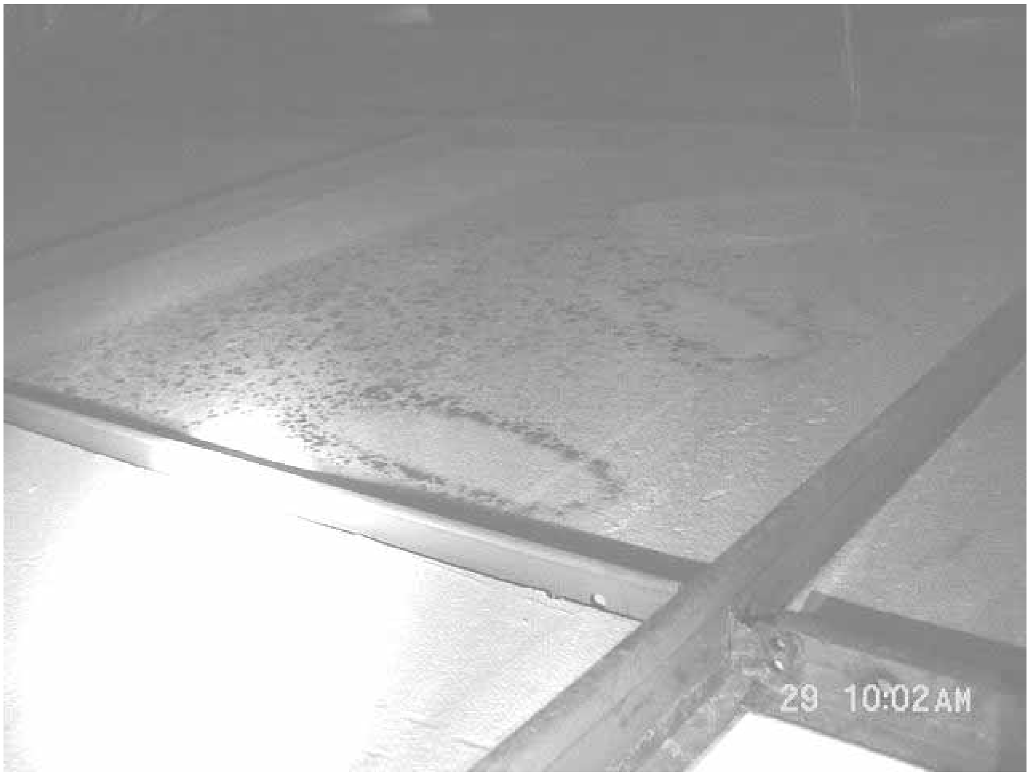
Picture 5

High-Efficiency Pleated Air Filters in Rooftop AHUs

Picture 6

Water Damaged Ceiling Tile with Possible Mold Growth, Picture Taken above Ceiling Tile System

Picture 7

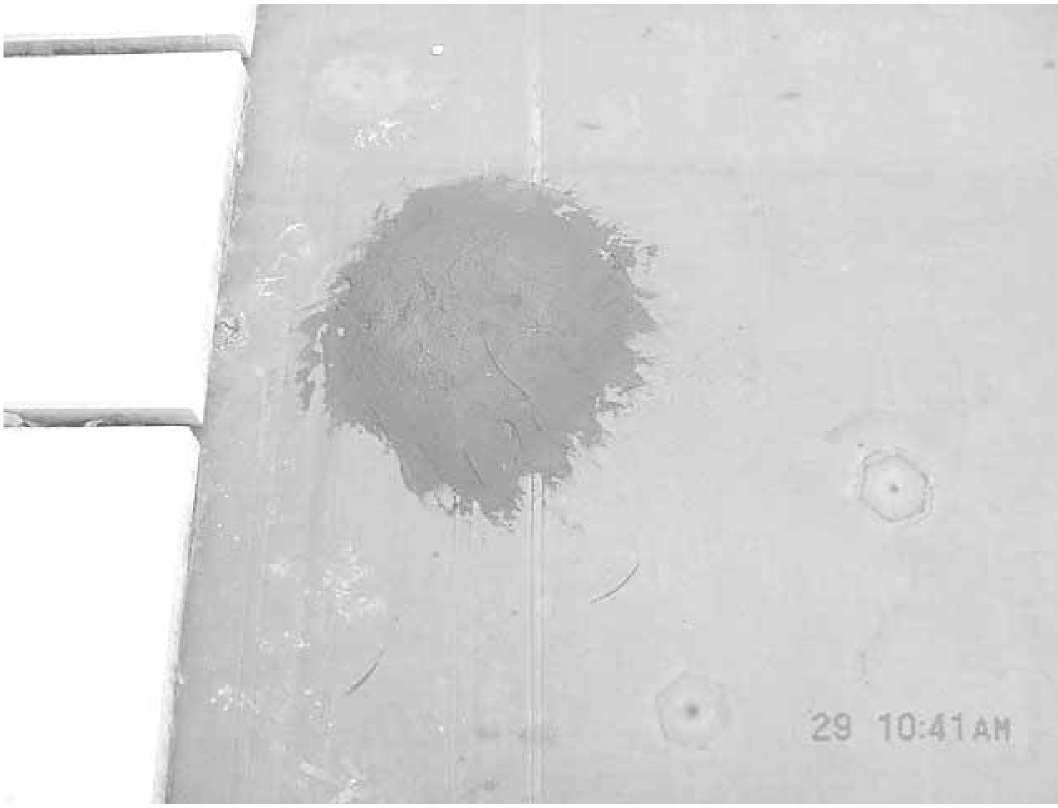


Water Damaged Ceiling Tile with Possible Mold Growth, Picture Taken above Ceiling Tile System

Picture 8

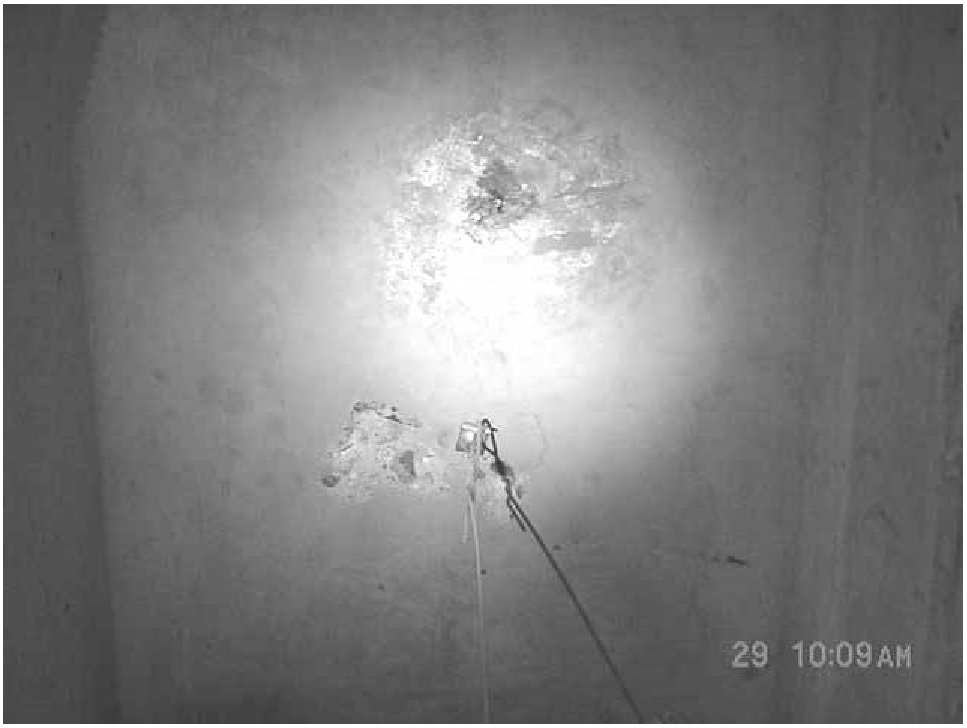
Water Damaged Ceiling Tiles being Removed/Replaced During Assessment

Picture 9



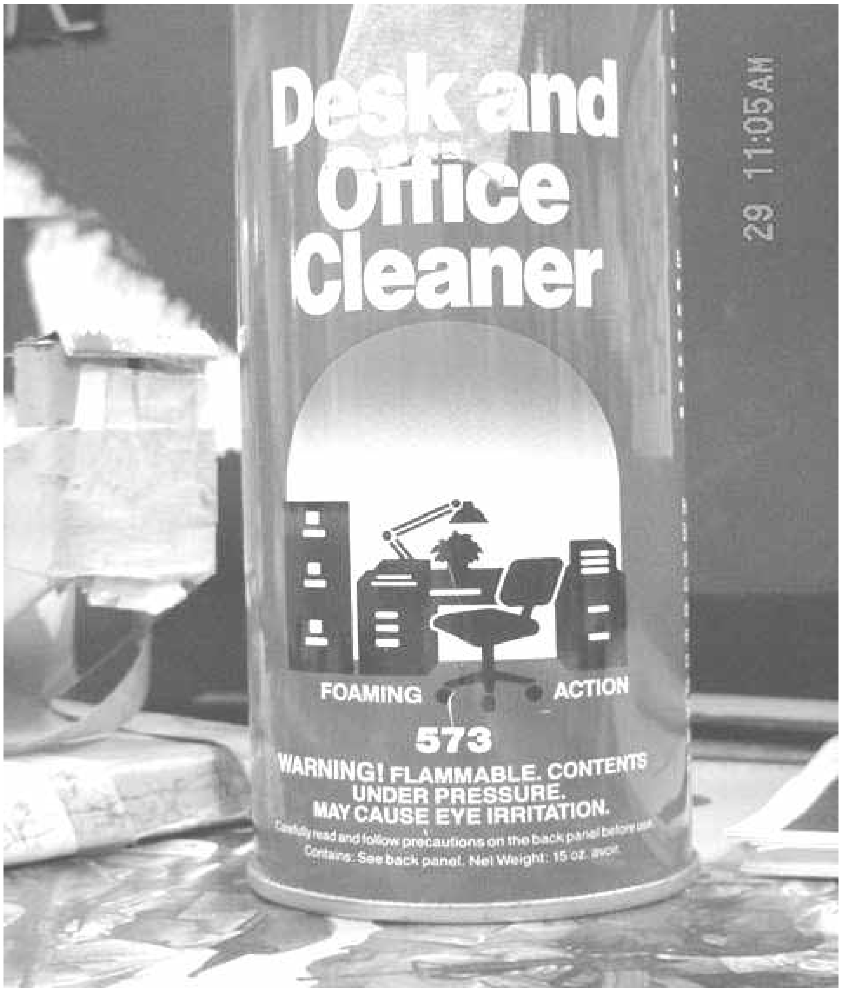
Roof Patch above Classroom 221

Picture 10



Holes/Breaches in Concrete Roof Decking above Ceiling Tiles in Classroom 221

Picture 11



Cleaning Compound found in Classroom, Note Warning Label for Eye Irritation

Hopedale Jr/Sr High School | **Indoor Air Results**

Hopedale, MA | **October 29, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	53	47	362	ND	ND	23		-	-	-	Atmospheric Conditions: cool, partly cloudy, west winds 5-10 mph
221	71	35	830	ND	ND	10	17	N	Y	Y	history of roof leaks (repaired Oct 18, 2004), 4 WD CTs-replaced during assessment, holes in concrete, CT low moisture content, DEM, cleaners, AP-not in use yet
223	71	36	891	ND	ND	8	15	N	Y	Y	No WD/leaks reported, DEM
229	74	35	943	ND	ND	12	0	N	Y	Y	Occupants gone 5-10 min
227	73	34	987	ND	ND	13	22	N	Y	Y	DEM
243	71	34	630	ND	ND	10	2	N	Y	Y	DEM, plants, DO
247	72	35	847	ND	ND	15	19	N	Y	Y	2 WD CTs- low moisture content, historic leak-repaired

ppm = parts per million parts of air
CT = ceiling tile
AD = air deodorizer
AP = air purifier
CD = chalk dust

µg/m3 = microgram per cubic meter
WD = water damage
DEM = dry erase marker
DO = door open
PC = photocopier

UV = univent
CF = ceiling fan
PF = personal fan
TB = tennis balls
UF = upholstered furniture

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Appendix A

Actions on MDPH Recommendations, Hopedale Junior/Senior High School, Hopedale, MA

The following is a status report of action(s) taken on MDPH recommendations (**in bold**) based on reports from town officials, school maintenance staff, documents, photographs and MDPH, BEHA staff observations.

- **Although cleaning has eliminated microbial growth from the carpet presently, further growth can be expected to occur once water moistens carpet in below grade areas. To avoid this occurrence, continue with plans to remove carpeting from below grade areas where mold was detected prior to the cleaning.**

  Action: Carpeting was not removed. School maintenance staff reported that the carpet is cleaned, dried and monitored for mold growth while the room is ventilated. No visible mold growth or odors were detected during the reassessment.
- **To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.**

  Action: Mechanical ventilation systems are operated continuously while the building is occupied.
- **Ensure univent air intakes controls are adjusted to allow the introduction of fresh air.**

Appendix A

Action: Univents were reportedly adjusted to increase the introduction of fresh air.

- **Remove all blockages from univents to ensure adequate airflow.**

  Action: Univent air diffusers and return vents were unobstructed.

- **Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary. Consider reducing the number of plants.**

  Action: Occupants were instructed in the proper care and placement of plants. No plants were observed on top of ventilation units.

- **Seal hole in exterior wall to prevent water intrusion and entry of pests.**

  Action: Utility holes on the exterior of the building were sealed.

- **Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.**

  Action: Chalk and dry erase board treys were clean and are reportedly vacuumed on a weekly basis.

- **Clean exhaust/return vents periodically to prevent excessive dust build-up.**

  Action: These vents are also reportedly vacuumed on a weekly basis.

- **Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.**

  Action: Tennis balls were replaced with felt covered plastic.